ISSN (print) 0093-4666 © 2014. Mycotaxon, Ltd. ISSN (online) 2154-8889

MYCOTAXON

http://dx.doi.org/10.5248/129.169

Volume 129(1), pp. 169–179 *July–September 2014*

Geastrum from the Atlantic Forest in northeast Brazil — new records for Brazil

Julieth de Oliveira Sousa[1*], Bianca Denise Barbosa da Silva[2], & Iuri Goulart Baseia[3]

[1]*Programa de Pós Graduação em Sistemática e Evolução, Universidade Federal do Rio Grande do Norte, Campus Universitário, PO Box 59072-970, Natal, RN, Brazil*

[2]*Programa de Pós Graduação em Biologia de Fungos, Universidade Federal de Pernambuco, Depto. Micologia, Centro de Ciências Biológicas, Av. Nelson Chaves, PO Box 50670-420, Recife, PE, Brazil*

[3]*Departamento de Botânica, Ecologia e Zoologia, Universidade Federal do Rio Grande do Norte, Campus Universitário, PO Box 59072-970, Natal, RN, Brazil*

*Correspondence to: *julieth.oliveira.sousa@gmail.com*

Abstract — Expeditions to remnants of the Brazilian Atlantic Forest in the Northeast Region resulted in three noteworthy *Geastrum* species. *Geastrum morganii* and *G. quadrifidum* are reported for the first time from Brazil, while *G. albonigrum* is reported for the second time in South America. Detailed descriptions with taxonomic observations, photos of basidiomes in situ, and SEM photos are provided.

Key words — *Geastraceae*, *Geastrales*, gasteroid fungi, taxonomy, biodiversity, neotropics

Introduction

The Atlantic Forest domain that covers most of the east South American coast represents one of the most extensive rainforests on the continent (Tabarelli et al. 2005). This biome, a biodiversity hotspot with a wide range of fungal species, is considered the second most threatened domain on the planet (Brooks et al. 2006, Myers et al. 2000). Northeastern Brazil encompasses four of the five centers of endemism that occur in the Brazilian Atlantic Forest and includes the most degraded sectors of this domain, harboring dozens of endangered species (Tabarelli et al. 2006).

In Brazil, knowledge of the gasteroid fungi in the Atlantic Forest has increased over the last ten years so that currently more than 40 gasteroid species have been recorded for this biome in the Northeast Region (Baseia 2004, 2005;

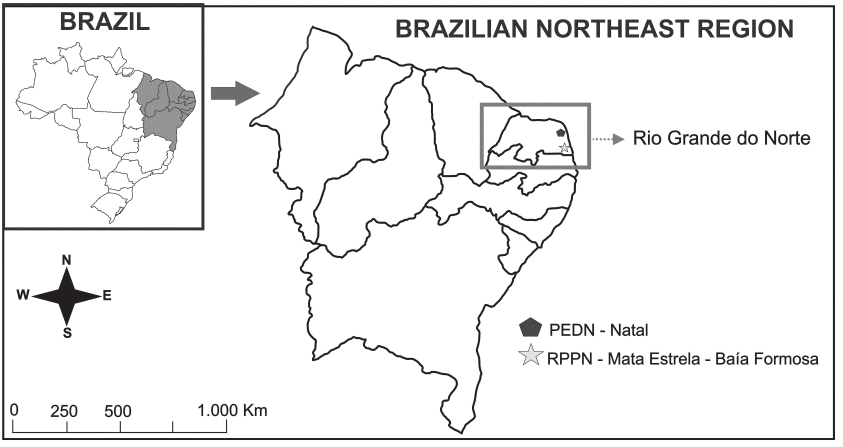

Figure 1. Map of Brazil's Northeast Region showing the remnants of Atlantic Rainforest studied.

Baseia et al. 2003a,b, 2006; Baseia & Calonge 2005, 2006, 2008; Leite & Baseia 2007; Leite et al. 2007a,b; Silva et al. 2007, 2013; Fazolino et al. 2008, 2010; Gurgel et al. 2008; Trierveiler-Pereira & Baseia 2009, 2011; Trierveiler-Pereira et al. 2009, 2010, 2011a; Barbosa et al. 2011; Cruz et al. 2012).

Sixteen *Geastrum* species have previously been reported from the northeastern Brazilian Atlantic Forest: *G. coronatum* Pers., *G. elegans* Vittad., *G. entomophilum* Fazolino et al., *G. fimbriatum* Fr., *G. fornicatum* (Huds.) Hook., *G. hieronymi* Henn., *G. hirsutum* Baseia & Calonge, *G. javanicum* Lév., *G. lageniforme* Vittad., *G. lloydianum* Rick, *G. ovalisporum* Calonge & Mor.-Arr., *G. saccatum* Fr., *G. schweinitzii* (Berk. & M.A. Curtis) Zeller, *G. setiferum* Baseia, *G. rusticum* Baseia et al., and *G. triplex* Jungh. These species were collected in various ecosystems including riparian, sand dunes, 'Restinga,' and coastal tableland. This work provides additional knowledge about *Geastrum* in Brazil.

Material & methods

Field expeditions were conducted during the rainy seasons of 2010 and 2012 to two Atlantic Forest remnants in Rio Grande do Norte State of northeastern Brazil (Fig.1): 'Parque Estadual Dunas de Natal' (PEDN) (5°50′31.23″S 35°11′39.21″W) and the 'Reserva Particular do Patrimônio Natural Mata Estrela' (RPPN Mata Estrela) (6°22′27.56″S 35°1′24.87″W). Tissues containing basidiospores, eucapillitium, and exoperidial hyphae were mounted in 5% KOH and then examined with an Olympus BX41 optical microscope, and scanning electron microscopy (SEM) was used to observe in detail basidiospore ornamentation, the eucapillitium, and the endoperidial surface

with a Phillips XL30-ESEM electronic microscope; preparation for SEM observation followed Silva et al. (2011). All measurements include basidiospore ornamentation. Basidiospore abbreviations follow Bates (2004): n = number of randomly measured basidiospores; x = mean ± standard deviation of basidiospore diameter and height (including ornamentation); Q_m = mean height/width quotient. Color descriptions were based on Kornerup & Wanscher (1978). All collected specimens were deposited in the Herbarium of the Federal University of Rio Grande do Norte, Natal, Brazil (UFRN).

Taxonomy

Geastrum albonigrum Calonge & M. Mata, Bol. Soc. Micol. Madrid 28: 332 (2004).
Plate 1

Unexpanded basidiome epigeous, globose to subglobose, 10–16 × 9–13 mm, surface hairy, brown (6E4) to dark brown (6E4), not encrusted with debris; rhizomorph ≤30 mm long, persistent. Expanded basidiome saccate, 10–13 × 17–26 mm. Exoperidium splitting into 5–7 revolute rays, non-hygroscopic. Mycelial layer grayish brown (6D3) to dark brown (6F4), hairy, not encrusted, peeling away in irregular patches with age exposing the fibrous layer. Fibrous layer white (4A1) to yellowish white (4A2), coriaceous, thick, glabrous, with rhizomorph attached. Pseudoparenchymatous layer dark brown (6F4, 6F3), glabrous to rimose, peeling away in irregular patches. Endoperidial body subglobose 11–13 × 10–11.5 mm, sessile, glabrous, dark brown (7F3), lightly pruinose, apophysis absent. Peristome fibrillose becoming lacerated with age, not delimited, concolorous with the endoperidium. Gleba grayish brown (7F2). Basidiospores globose to subglobose, 3.8–5 × 3.8–5 µm [x = 4.6 ± 0.2 × 4.6 ± 0.4 µm, Q_m = 1.01, n = 30], brownish, verrucose; warts short cylindrical with rounded tips; apiculus inconspicuous. Eucapillitium 2.5–5 µm diam., walls straight, encrusted, lumen present, surface verrucose, brown. Mycelial layer composed of sinuous-walled hyphae, 2.5–5 µm diam., lumen absent, brownish. Fibrous layer composed of straight-walled hyphae, 2.5–5 µm diam., greenish yellow to hyaline, lumen absent. Pseudoparenchymatous layer composed of thin-walled (<1 µm) hyphal cells, subglobose to pyriform hyphae, 26.6–53.3 × 16.5–34.2 µm, hyaline to yellowish.

Substrate: Sandy soil covered with litter and decaying wood.

Specimens examined: **BRAZIL. Rio Grande do Norte**: Baía Formosa, RPPN Mata Estrela, 14.VII.2011, leg. J.O. Sousa & B.D.B. Silva (UFRN-Fungos 1745); 14.VII.2011, leg. B.D.B. Silva & J.O Sousa (UFRN-Fungos 1747).

Distribution: Central America: Costa Rica (Calonge & Mata 2004); North America: Mexico (Calonge & Mata 2004); South America: Brazil, Mato Grosso State (Treirveiler-Pereira et al. 2011b), Rio Grande do Norte State (this paper).

Taxonomic remarks: *Geastrum albonigrum* is characterized by the pseudoparenchymatous layer and black endoperidium, white fibrous layer

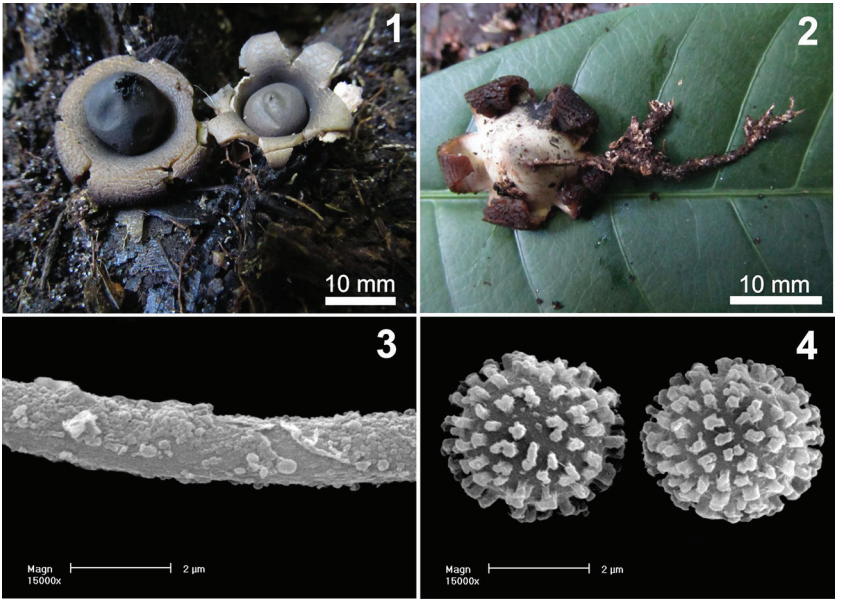

Plate 1. *Geastrum albonigrum*. 1. Fresh basidiomes (UFRN-Fungos 1745). 2. Basidiome showing the rhizomorph (UFRN-Fungos 1747). 3. Eucapillitium (SEM) (UFRN-Fungos 1745). 4. Basidiospores (SEM) (UFRN-Fungos 1745).

with adhering rhizomorphs, and ephemeral hairy mycelial layer. *Geastrum coronatum*, *G. lloydianum*, and *G. ovalisporum* also exhibit dark endoperidia, but these species differ by arched basidiomes, pedicellate endoperidia with apophysis, and delimited peristomes (Ponce de Leon 1968, Sunhede 1989, Calonge et al. 2000, Bates 2004). *Geastrum hirsutum* has immature basidiomes very similar to those of *G. albonigrum*, being globose to subglobose with their surfaces covered with hairs. However, *G. hirsutum* exhibits distinctly expanded basidiomes with smaller basidiospores (2.5–3 µm), persistent mycelial layer, a delimited peristome, grayish endoperidium and the presence of a well-developed subiculum (Calonge & Mata 2004, Baseia & Calonge 2006). *Geastrum fimbriatum* is also a closely related species, distinguished by the light brown to grayish brown endoperidium, hairless mycelial layer with incrustations, and rhizomorphs that are absent in the expanded basidiome (Sunhede 1989, Bates 2004, Calonge & Mata 2004). Our SEM image of the eucapillitium demonstrating a verrucose surface and photos of the fresh expanded basidiome augment the protologue of *G. albonigrum*. This constitutes a second report for South America and a first report for northeastern Brazil for *Geastrum albonigrum*.

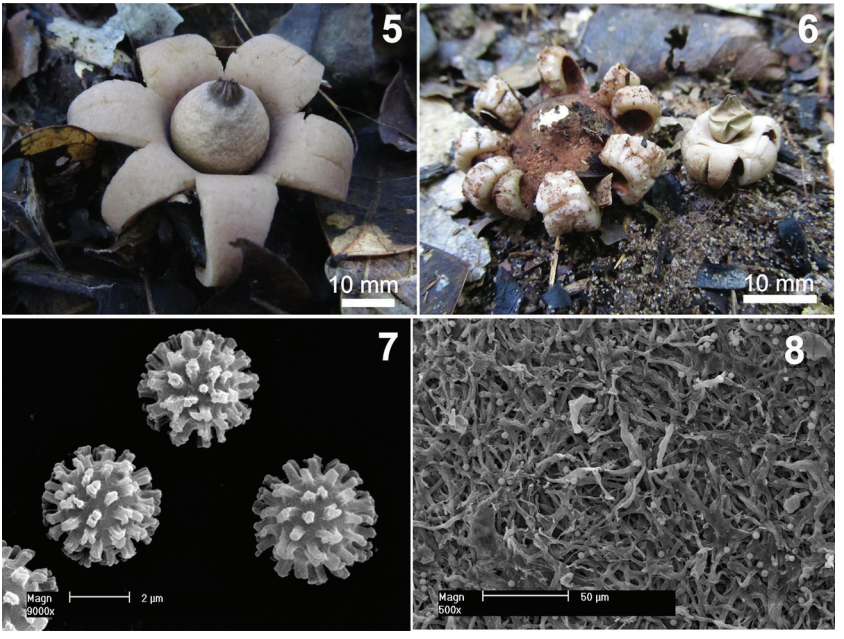

Plate 2. *Geastrum morganii*. 5–6. Fresh basidiome (UFRN- Fungos 1793) – (UFRN- Fungos 1744). 7. Basidiospores (SEM) (UFRN- Fungos 1793). 8. Surface of the endoperidium (SEM) (UFRN- Fungos 1793).

Geastrum morganii Lloyd, Myc. Writ. 1: 80 (1901). Plate 2

Unexpanded basidiome epigeous, lageniform, subglobose to irregular, 24 × 16 mm, surface papery to rugulose, brown (6E4) to yellowish brown (5D5), not encrusted, rhizomorph not observed. Expanded basidiome saccate to arched, 9–28 × 10–62 mm. Exoperidium splitting into 6–7 rays, revolute to arched, elongated with slender tips, non-hygroscopic. Mycelial layer brown (6E5) to dark brown (6F5), papery, not encrusted, persistent or peeling away with age. Fibrous layer yellowish white (4A2) to white orange (5A2), coriaceous, rigid. Pseudoparenchymatous layer dark brown (7F4), thick (≤3 mm when fresh), peeling away in irregular patches from the base of the rays, forming longitudinal cracks or a collar-like structure surrounding the endoperidium. Endoperidial body globose to subglobose, 6–24 × 7–26 mm, sessile, with protruding hyphae, orange brown (5C3) to light brown (6D4), apophysis absent. Peristome irregularly plicate, not delimited, conical, with 5–11 irregular folds, 2–4 mm high, lighter or darker than the endoperidium. Gleba dark brown (7F3). Basidiospores globose to subglobose, 3.8–6(–6.9) × 3.8–6(–6.8) µm [x = 5.3 ± 0.4 × 5.2 ± 0.4 µm, Q_m = 1.03, n = 30], dark brown, strongly verrucose; verrucae

long and columnar with plane tips, slightly truncated; apiculus inconspicuous. Eucapillitium 2.5–6 µm diam., walls sinuous thin (<1 µm), surface encrusted, verrucose, yellowish white. Mycelial layer composed of thick (>1 µm) sinuous-walled hyphae, 2.5–4.0 µm diam., lumen absent, clamp connections present, yellowish. Fibrous layer composed of straight-walled hyphae, 2.5–5 µm diam., lumen absent, hyaline to slightly greenish. Pseudoparenchymatous layer composed of thin-walled (<1 µm) hyphal cells, oval, ellipsoid to pyriform, 29.2–82.5 × 20–42 µm, hyaline to slightly brownish. Endoperidium with protruding hyphae agglutinated.

Substrate: Sandy soil covered with litter.

Specimens examined: **BRAZIL. Rio Grande do Norte**: Baía Formosa, RPPN Mata Estrela, 14.VII.2010, leg. B.D.B. Silva, J.O. Sousa & I.G. Baseia (UFRN-Fungos 1744); 14.VII.2011, leg. J.O. Sousa & B.D.B Silva (UFRN-Fungos 1746); 14.VII.2012, leg. J.O. Sousa, B.D.B. Silva & J.C. Bezerra (UFRN-Fungos 1793); Serra Negra do Norte, Estação Ecológica do Seridó, 19.IV.2008, leg. E.P Fazolino, B.B.B. Silva & J.J.S. Oliveira (UFRN-Fungos 816).

Distribution: Africa: Congo (Dissing & Lange 1962); Central America: Costa Rica (Calonge & Mata 2006); Europe: France (Sunhede 1989); North America: United States (Coker & Couch 1928), Hawaii (Hemmes & Desjardin 2011); South America: Argentina (Caffot et al. 2013), Brazil (this paper).

Taxonomic remarks: This species is characterized by its non-delimited, irregularly plicate peristome, a mycelial layer lacking incrustations, saccate to arched basidiomes, and a sessile endoperidium (Hemmes & Desjardin 2011, Sunhede 1989). Some *G. morganii* basidiomes may develop a collar-like structure around the endoperidium as in *G. triplex*, but the latter is distinguished by the delimited fibrillose peristome and basidiomes larger than 25–150 mm (Sunhede 1989). *Geastrum morganii* is also very similar to *G. elegans*, which differs by its distinctly delimited peristome with a larger number of regular folds (10–20), a mycelial layer encrusted with debris, and a slightly pruinose endoperidium (Sunhede 1989, Bates 2004, Calonge & Mata 2006). *Geastrum reticulatum* Desjardin & Hemmes from Hawaii is morphologically similar but differs from *G. morganii* in the immature basidiomata with hyphae projecting above the surface, as well as a regularly plicate peristome that is distinctly delimited and depressed in the endoperidium (Hemmes & Desjardin 2011). *Geastrum episcopale* F. Kuhar & L. Papin., which can be confused with *G. morganii*, has smaller basidiospores (approximately 2.2 µm in diam.), calcium oxalate crystals on the endoperidium and a magenta exoperidium and purple endoperidium (Kuhar & Papinutti 2009). Calonge (1998) considers *G. morganii* as the American form of *G. badium* Pers., but Sunhede (1989) regards them as different species. This is the first report of *G. morganii* from Brazil.

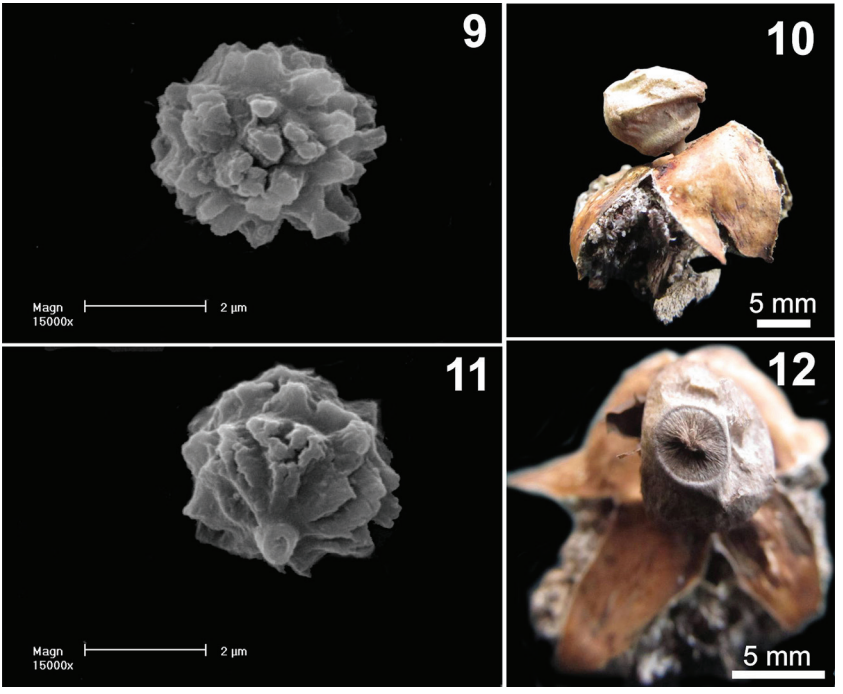

Plate 3. *Geastrum quadrifidum* (UFRN-Fungos 1748). 9–11. Basidiospores (SEM). 10–12. Dry basidiomes.

Geastrum quadrifidum Pers., Neues Mag. für die Bot. 1: 86 (1794). Plate 3

Unexpanded basidiome not observed. Expanded basidiome fornicate, 11 × 26 mm. Exoperidium splitting into 5 rays, fornicate, adhering to the mycelial layer, non-hygroscopic. Mycelial layer yellowish white (4A2), felted, encrusted with organic matter and sand, persistent, forming a cup under the basidiome. Fibrous layer white orange (5A2), papery, thin. Pseudoparenchymatous layer brown (6E5), rigid, peeling away in irregular patches with age to expose the fibrous layer. Endoperidial body subglobose, 8 × 9 mm, stalked, brownish orange (5C3), slightly pruinose. Stalk 1.5 mm high, distinct, lighter than the endoperidium. Apophysis reduced, concolorous with the endoperidium. Peristome fibrillose, distinctly delimited, delimitation white orange (5A2), mammiform, concolorous with to darker than endoperidium. Gleba dark brown (6F4). Basidiospores globose to subglobose, 3.8–6.3 µm × 3.8–6 µm [$x = 5.4 \pm 0.5 \times 5 \pm 0.7$, Qm = 1.1, n = 30], brownish, densely verrucose; verrucae long, columnar, truncate, with planar or confluent tips; apiculus prominent,

surrounded by columnar processes. Eucapillitium 1.9–6.3 µm diam., thick sinuous walls (>1 µm), encrusted, lumen absent, surface glabrous, yellowish brown. Mycelial layer composed of thin hyphae, <1 µm diam., hyaline. Fibrous layer composed of thin straight-walled (<1 µm) hyphae, 2.5–6.8 µm diam., lumen absent, hyaline to slightly yellowish. Pseudoparenchymatous layer composed of collapsed thick-walled (>1 µm) hyphal cells, subglobose to oval, brownish.

Substrate: Sandy soil.

Specimen examined: **BRAZIL. Rio Grande do Norte**: Natal, Parque Estadual Dunas do Natal, 3.IV.2012, leg. J.O. Sousa, R.H.S.F. Cruz & J.C Bezerra (UFRN-Fungos 1748).

Distribution: Africa: South Africa (Bottomley 1948); Asia: Japan (Kasuya et al. 2011); Europe: Spain (Calonge 1998), England (Pegler et al. 1995, Demoulin & Marriott 1981), Norway (Eckblad 1995), Estonian, Finland, Latvia, Sweden, Norway, (Sunhede 1989); North America: United States (Bates 2004), Hawaii: (Smith & Ponce de Leon 1982); South America: Argentina (Soto & Wright 2000), Brazil (this paper).

Taxonomic remarks: *Geastrum quadrifidum* is characterized by the fornicate basidiome, a small (4–6) number of rays, a mycelial layer forming a cup on the expanded basidiome, and a distinctly delimited fibrillose peristome (Bates 2004, Sunhede 1989). *Geastrum minimum* Schwein. is distinguished by larger (5–11) number of rays, a densely pruinose endoperidium, and basidiomes that are frequently not fornicate (Bates 2004, Sunhede 1989). *Geastrum quadrifidum* also resembles *G. fornicatum*, which differs by its larger basidiomes (≤40 mm wide), a non-delimited peristome, basidiospores with rarely confluent warts, and an endoperidium with projecting hyphae (Bates 2004, Sunhede 1989). Another closely related species, *G. leptospermum* G.F. Atk. & Coker, is distinguished by the smaller basidiomes (2–3 mm wide) (Bates 2004). The also similar *G. welwitschii* Mont. is distinguished by its indistinctly delimited peristome and a mycelial layer lacking incrustations (Calonge 1998). This is the first report of *G. quadrifidum* from Brazil.

Acknowledgments

The authors gratefully acknowledge the CTPETRO-INFRA and FINEP/LIEM for their collaboration with scanning electron microscopy. The authors express their thanks to Johannes C. Coetzee (Cape Peninsula University of Technology, Bellville, South Africa) and Felipe Wartchow (Universidade Federal da Paraíba, Brazil) for reviewing the manuscript. This work was financed by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Conselho Nacional de Desenvolvimento Cientifico e Tecnológico (CNPq).

Literature cited

Barbosa MMB, Silva, MP, Cruz, RHSF, Calonge, FD, Baseia IG. First report of *Morganella compacta* (*Agaricales, Lycoperdaceae*) from South America. Mycotaxon 116: 381–386. http://dx.doi.org/10.5248/116.381

Baseia IG. 2004. Contribution to the study of the genus *Calvatia* (*Lycoperdaceae*) in Brazil. Mycotaxon 88: 107–112.

Baseia IG. 2005. Some notes on the genera *Bovista* and *Lycoperdon* (*Lycoperdaceae*) in Brazil. Mycotaxon 91: 81–86.

Baseia IG, Calonge FD. 2005. *Aseroë floriformis*, a new phalloid with a sunflower-shaped receptacle. Mycotaxon 91: 169–172.

Baseia IG, Calonge FD. 2006. *Geastrum hirsutum*: a new earthstar fungus with a hairy exoperidium. Mycotaxon 95: 301–304.

Baseia IG, Calonge FD. 2008. *Calvatia sculpta*, a striking puffball occurring on Brazilian sand dunes. Mycotaxon 106: 269–272.

Baseia IG, Cavalcanti MA, Milanez, AI. 2003a. Additions to our knowledge of the genus *Geastrum* (*Phallales: Geastraceae*) in Brazil. Mycotaxon 85: 409–416.

Baseia IG, Gibertoni TB, Maia, LC. 2003b. *Phallus pygmaeus*, a minute species from a Brazilian tropical rain forest. Mycotaxon 85: 77–80.

Baseia IG, Calonge FD, Maia LC. 2006. Notes on the *Phallales* in Neotropics. Boletín de la Sociedad Micológica de Madrid 30: 87–93.

Bates ST. 2004. Arizona members of the *Geastraceae* and *Lycoperdaceae* (*Basidiomycota*, *Fungi*). Master's Thesis. Arizona State University, Tempe.

Bottomley AM. 1948. Gasteromycetes of South Africa. Bothalia 4: 473–810.

Brooks TM, Mittermeier RA, Fonseca GAB, Gerlach J, Hoffmann M, Lamoreux JF, Mittermeier CG, Pilgrim JD, Rodrigues ASL. 2006. Global biodiversity conservation priorities. Science 13: 58–61. http://dx.doi.org/10.1126/science.1127609

Cabral TS, Silva BDB, Marinho P, Baseia IG. 2014. *Geastrum rusticum* (Geastraceae, Basidiomycota), a new earthstar fungus in the Brazilian Atlantic rainforest – a molecular analysis. Nova Hedwigia 98: 265–272. http://dx.doi.org/10.1127/0029-5035/2013/0158

Caffot MLH, Robledo G, Domínguez LS. 2013. Gasteroid mycobiota (*Basidiomycota*) from *Polylepis australis* woodlands of central Argentina. Mycotaxon 123-491. http://dx.doi.org/10.5248/123.491

Calonge FD. 1998. *Gasteromycetes*. I. *Lycoperdales*, *Nidulariales*, *Phallales*, *Sclerodermatales*, *Tulostomatales*. Flora Mycologica Iberica 3: 1–271.

Calonge FD, Mata M. 2004. A new species of *Geastrum* from Costa Rica and Mexico. Boletín de la Sociedad Micológica de Madrid 28: 331–335.

Calonge FD, Mata M. 2006. Adiciones e Correcciones al Catálago de *Gasteromycetes* da Costa Rica. Boletín de la Sociedad Micológica de Madrid 30: 111–119.

Calonge FD, Moreno-Arroyo B, Gómez J. 2000. Aportación al conocimiento de los *Gasteromycetes*, *Basidiomycotina*, de Bolivia (América del Sul). *Geastrum ovalisporum* sp. nov. Boletín de la Sociedad Micológica de Madrid 25: 271–275.

Coker WC, Couch JN. 1928. The *Gasteromycetes* of the eastern United States and Canada. University of North Carolina Press, Chapel Hill, 283 p.

Cruz RHSF, Barbosa M, Baseia IG. 2012. *Cyathus badius* and *C. earlei* reported from Brazilian Atlantic rain forest. Mycotaxon 121: 365–369. http://dx.doi.org/10.5248/121.365

Demoulin V, Marriott JVR. 1981. Key to the *Gasteromycetes* of Great Britain. Bulletin of the British Mycological Society 15: 37–56.

Dissing H, Lange M. 1962. *Gasteromycetes* of Congo. Bulletin du Jardin Botanique de l'État 32: 325–416.

Eckblad FE. 1955. The *Gasteromycetes* of Norway. The epigean genera. Nytt Magasin for Botanikk 4: 19–86.

Fazolino EP, Calonge FD, Baseia IG. 2008. *Geastrum entomophilum*, a new earthstar with an unusual spore dispersal strategy. Mycotaxon 104: 449–453.

Fazolino EP, Trierveiler-Pereira L, Calonge FD, Baseia IG. 2010. First records of *Clathrus* (*Phallaceae*, *Agaricomycetes*) from the Northeast Region of Brazil. Mycotaxon 113: 195–202. http://dx.doi.org/10.5248/113.195

Gurgel FE, Silva BDB, Baseia IG. 2008. New records of *Scleroderma* from Northeastern Brazil. Mycotaxon 105: 399–405.

Hemmes DE, Desjardin DE. 2011. Earthstars (*Geastrum, Myriostoma*) of the Hawaiian Islands including two new species, *Geastrum litchiforme* and *Geastrum reticulatum*. Pacific Science 65: 477–496. http://dx.doi.org/10.2984/65.4.477

Kasuya T, Hosaka K, Sakamoto H, Uchida A, Hoshino T, Kakishima M. 2011. New records of *Geastrum* from Japanese sand dunes. Mycotaxon 118: 1–15. http://dx.doi.org/10.5248/118.1

Kornerup A, Wansher JE. 1978. Methuen handbook of colour, 3rd edn. Eyre Methuen, London. 252 p.

Kuhar F, Papinutti L. 2009. *Geastrum episcopale*: a new noticeable species with red-violet exoperidium. Mycologia 101: 535–538. http://dx.doi.org/10.3852/08-029

Leite AG, Baseia IG. 2007. Novos registros de *Geastraceae* Corda para o Nordeste Brasileiro. Sitientibus. Série Ciências Biológicas 7: 178–183.

Leite AG, Calonge FD, Baseia IG. 2007a. Additional studies on *Geastrum* from Northeastern Brazil. Mycotaxon 101: 103–111.

Leite AG, Silva BDB, Araújo RS, Baseia IG. 2007b. Espécies raras de *Phallales* (*Agaricomycetidae, Basidiomycetes*) no Nordeste do Brasil. Acta Botanica Brasilica 21: 119–124.

Myers N, Mittermeier RA, Mittermeier CG, Fonseca GAB, Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858. http://dx.doi.org /10.1038/35002501

Pegler DN, Læssøe T, Spooner BM. 1995. British puffballs, earthstars, and stinkhorns. Royal Botanic Gardens, Kew. 211 p.

Ponce de León P. 1968. A revision of the family *Geastraceae*. Fieldiana Botany 31: 302–349.

Silva BDB, Calonge FD, Baseia IG. 2007. Studies on *Tulostoma* (*Gasteromycetes*) in the Neotropics. Some Brazilian species. Mycotaxon 101: 47–54.

Silva BDB, Sousa JO, Baseia IG. 2011. Discovery of *Geastrum xerophilum* from the Neotropics. Mycotaxon 118: 355–359. http://dx.doi.org/10.5248/118.355

Silva BDB, Cabral TS, Marinho P, Ishikawa NK, Baseia IG. 2013. Two new species of *Geastrum* (*Geastraceae*, *Basidiomycota*) from Brazil. Nova Hedwigia 96: 445–456.

Smith CW, Ponce de Leon P. 1982. Hawaiian gasteroid fungi. Mycologia 74: 712–717.

Soto MK, Wright JE. 2000. Taxonomia del genero *Geastrum* (*Basidiomycetes, Lycoperdales*) em la Provincia de Buenos Aires, Argentina. Boletín de la Sociedad Argentina de Botanica 34: 185–201.

Sunhede S. 1989. *Geastraceae* (*Basidiomycotina*). Morphology, ecology, and systematics with special emphasis on the North European species. Synopsis Fungorum 1. 534 p.

Tabarelli M, Pinto LP, Silva JMC, Hirota M, Bedê L. 2005. Challenges and opportunities for biodiversity conservation in the Brazilian Atlantic Forest. Conservation Biology 19: 695–700.

Tabarelli M, Melo MDVC, Lira OC. 2006. Nordeste e Estados do Nordeste, menos Sergipe. 149–164. In: M. Campanili& M. Prochnow (eds.). Mata Atlântica: Uma rede pela floresta. Brasília, Rede de ONGs da Mata Atlântica (RMA).

Trierveiler-Pereira L, Baseia IG. 2009. Revision of the Herbarium URM IV. *Nidulariaceae* (*Basidiomycota*). Nova Hedwigia 89: 361–369.

Trierveiler-Pereira L, Baseia IG. 2011. Contribution to the knowledge of gasteroid fungi (*Agaricomycetes*, *Basidiomycota*) from the state of Paraíba, Brazil. Revista Brasileira de Biociências 9: 167–173.

Trierveiler-Pereira L, Bezerra KMT, Bezerra JL, Baseia IG. 2009. First records of *Geastraceae* and *Nidulariaceae* (*Basidiomycota*, *Fungi*) from Bahia, Northeastern Brazil. Biociências (Porto Alegre), 7: 316–319.

Trierveiler-Pereira L, Kreisel H, Baseia IG. 2010. New data on puffballs (*Agaricomycetes*, *Basidiomycota*) from the Northeast Region of Brasil. Mycotaxon 111: 411–421. http://dx.doi.org/10.5248/111.411

Trierveiler-Pereira L, Calonge FD, Baseia IG. 2011a. New distributional data on *Geastrum* (*Geastraceae, Basidiomycota*) from Brazil. Acta Botanica Brasilica 25: 577–585.

Trierveiler-Pereira L, Gomes–Silva AC, Baseia IG. 2011b. Observations on gasteroid *Agaricomycetes* from the Brazilian Amazon rainforest. Mycotaxon 118: 273–282. http://dx.doi.org/10.5248/118.273